CHAPTER 3

ANALYSIS OF SIGNIFICANT HARM FACTORS

This chapter contains information used by staff to formulate recommendations for minimum aquifer level for aquifers in the Lower West Coast planning area. It consists of a summary of technical information that was considered within the statutory guidelines provided the districts in the establishment of minimum levels. More detailed and extensive data on the aquifer characteristics and use are available in the selected references included at the end of this report.

I. Consideration/Exclusions

As discussed in Chapter 1, when establishing minimum flows and levels, the Governing Board shall consider changes and structural alterations to watersheds, surface waters and aquifers and the effects such changes have on the hydrology of the affected water body. In addition, the legislature also recognizes that certain water bodies serve their historical hydrologic functions and that setting an MFL based on its historical condition may not be appropriate.

Staff has evaluated existing data to identify any long-term changes to the aquifers that should be considered in the establishment of minimum levels. Review of historic data reveals that the principle changes in the LWC aquifers have been reductions in water levels/potentiometric head. In some localized areas there have also been changes in groundwater quality.

Figures 11 through 14 consist of a series of hydrographs showing changes to the water levels over time. Monitor wells, which show the greatest reductions in water levels, are located adjacent to large production wells and in confined aquifers with low transmissivities, storativity, and leakance. Water levels within the Mid-Hawthorn aquifer in central Lee County have dropped approximately 60 to 80 feet below estimated pre-development levels. The pre-development levels for this aquifer were about 10 to 20 feet NGVD (or approximately 5 to 10 feet above land surface) in western Lee County. However, beginning in the early 1970s, the potentiometric head began to decline in response to increase use of the aquifer by public water supply wellfields and increasing numbers of domestic wells. Figure 11, of monitor well L-581 located in Cape Coral, shows how these declines have continued over the past twenty-five years.

Declines on over 30 feet below pre-development levels occur locally in the Floridan aquifer system near the public water supply wellfields of Cape Coral (Figure 12). The declines in the FAS are more recent, triggered by the shift to this source by Cape Coral, Greater Pine Island and Sanibel Island during the last 25 years. This aquifer system is well confined, with low storage and leakance which causes the large drawdowns under moderate pumpage.

The potentiometric levels within portions of the Sandstone aquifer have also declined as much as 30 feet seasonally in the agricultural areas of western Hendry and eastern Lee counties. Water level changes of 15 feet or less occur in the Lower Tamiami aquifer near the major

wellfield in Collier County. The main difference between the water level changes observed in the FAS/Mid-Hawthorn aquifer and the Sandstone/Lower Tamiami aquifers is that the water levels recover to near pre-development levels in the shallower aquifers during the wet season. This is attributed to several factors including a higher hydraulic connection between these aquifers and the Water Table and the seasonality of the agricultural demands that utilize these two aquifers.

There are no long-term declines in the Water Table aquifer. This is attributed to the limitations on yield and water quality (color and iron), the consumptive use permit constraints on impacts to wetland and saltwater intrusion, the unconfined nature of the aquifer, high annual rainfall and flat, low lying topography.

Water quality changes are much more localized and variable. The long term changes to water quality reflect both declines and improvements. Principal changes to the Water Table aquifer have been related to point source contaminants associated with land use such as gas stations, and industrial sites. Monitor data collected along the coast show no signs of long-term saline intrusion although chloride levels do fluctuate seasonally. Water quality data for the semi-confined aquifer show some instances of localized saline water changes associated with water use. In many cases, the water quality has actually improved due to the cementing in of old abandoned free flowing wells originally constructed into the FAS. These well were drilled in the 1940s for agriculture and were short cased. The short casing allowed the high-pressure water to invade the shallow freshwater aquifers. During the 1980s, the District and local governments located and cemented-in over 250, six-to-ten inch diameter wells stopping the uncontrolled flow of approximately 400 million gallons per day of saline water.

In other areas, salinity has increased due to pumping. These cases occur in the FAS wellfields, which de-salt the deep saline waters. In a few of the production wells, dissolved chloride levels increased as a function of upconing of deeper saline water caused by the lowering of head pressure at the production wells. District consumptive use permit rules allow for controlled degradation of a saline source of supply as long as the use remains sustainable and no harmful impacts occur to other legal users.

No other data was found relating to other changes in time-invariant aquifer characteristics such as permeability, storage etc. No data was found pertaining to structural alterations to the aquifers

Based on these factors, staff has concluded the following:

1) No structural alterations have occurred to the subject aquifers on a scale to be considered in the establishment of MFL's

2) The changes to the aquifers (ground water levels and quality) as related to pre-development conditions are attributed to consumptive use withdrawals, which have not resulted in impacts to the aquifer function as a water supply source. These changes are, therefore, considered to be acceptable under Section 373.0421(1)(a), F.S.

3) The aquifers are found to continue to provide their historic hydrologic function and therefore no exclusions are proposed for the subject aquifers.

II. Water Resource Functions of LWC Aquifers

Chapter 62-40.405 F.A.C. identifies several environmental values associated with coastal, estuarine, aquatic and wetland systems that shall be given consideration when adopting MFLs. The following summarizes the staff's evaluation regarding applicability of these functions.

Water Resource Function	Evaluated for MFL
Fish and wildlife habitat and the passage of fish	Yes for Water Table aquifer
Maintenance of freshwater storage and supply	Yes
Water quality	Yes
Estuarine resources	Yes for Water Table aquifer
Transfer of detrital material	Not Applicable for Aquifers
Filtration and absorption of nutrients and pollutants	Not Applicable for Aquifers
Sediment loads	Not Applicable for Aquifers
Recreation in and on the water	Not Applicable for Aquifers
Navigation	Not Applicable for Aquifers
Aesthetic and scenic attributes	Not Applicable for Aquifers
Recreation in or on the water, fish and wildlife habitats	Not Applicable to LWC aquifers

With regard to the aquifers in the Lower West Coast planning area, only the Water Table aquifer has hydrologic connections to surface water features. Two of these values, fresh water storage/supply and water quality, are functions that are applicable to the Water Table and semi-confined aquifers in the area. In addition, staff considered the function of structural support/subsidence in developing the MALs for the aquifers. What follows is an evaluation of the functions of each aquifer and an analysis of available data related to these functions.

III. Evaluation of Significant Harm

Water Table Aquifer: The principal functions associated with the Water Table aquifer includes base flow to streams, creeks and rivers etc., water supply to wetland systems, water supply to man and structural support. Lowering the water levels within the aquifer potentially affects all of these functions.

The relationship between groundwater levels, seasonal variation of rainfall and resulting hydrologic responses of isolated wetlands in Lee County is presented in a study by Shaw and Huffman, 2000. This study also looks at the aspects of consumptive use withdrawals on wetland hydrology as well. The report clearly shows that the potential for harmful impacts to wetlands exists should CUP withdrawals go unmanaged.

In studies conducted in the Southwest Florida Water Management District (SWFWMD), documentation of the destruction of wetland habitats including loss of hydropattern, loss of organic soils, falling mature cypress trees, etc. is attributed to excessive Water Table drawdowns from nearby wellfields. Shaw studied these impacts and proposed an impact characterization system based on the degree of hydrologic alteration. The impacts range from no harm to significant and serious harm. His observations suggested that while lowered groundwater levels impact isolated wetlands, the more severe impacts occur when the lowered levels are sustained for multiple years. Along this line, Shaw identifies that changes to surface water features, such as a road which transects wetland, housing developments which encroach into wetlands and drainage features, have had far more impacts to wetland hydrology than consumptive uses.

Isolated wetlands appear resilient to seasonal declines in water levels greater than five feet below land surface for several months provided normal rainfall patterns return in the wet season and ground water levels recover to normal pool. Water uses, which prevent this wet season groundwater level rebound, will harm these systems.

The SWFWMD has adopted MFLs for isolated lakes and wetland systems based on a statistical analysis of three categories of wetlands: non-impacted, impacted and significantly impacted. An extensive network of monitored wetlands facilitated the methodology used by SWFWMD. Such a monitor network did not exist in the SFWMD until recently when the agency has funded a wetland monitor program in the amount of approximately $2.5 million. This monitor program is beginning its fourth year of development with approximately three additional years of data collection anticipated. At this time, staff is of the opinion that further data collection and analysis is needed to better define the hydrologic deficits that would result in significant harm to isolated wetlands.

In a similar situation, very little data exists with regard to groundwater base flows to rivers, streams, creeks and sloughs within the study area. At this time, the Caloosahatchee River downstream of S-79, is the only surface water body on the District's MFL priority water body list. There are several other rivers, creeks and sloughs within the study area where the relationship between groundwater and surface water flows and levels should be evaluated. These water bodies include the Imperial, Estero and the Orange rivers, the Fakahatchee Canal, and the Six Mile Cypress Slough. These water bodies, and others, are included in the scope of the study for the Southwest Florida Feasibility Study. This study is a joint venture between the United States Army Core of Engineers and the District. It is anticipated to be completed in three years and will focus on the ecological functions and hydrologic needs of southwest Florida.

Data resulting from this study may be used to define MFLs for the above-mentioned surface water bodies. In the mean time, the impact of withdrawals from the Water Table aquifer was evaluated within a half-mile radius of each of these water bodies and is summarized in Figure 15 and Table 6.

Considering the relatively low demands on the Water Table, the distance from the surface water body, and the low permeability of the aquifer, it is not anticipated that consumptive use

withdrawal will result in significant harm to these water bodies prior to the completion of the Southwest Florida Feasibility Study.

Water supply for man's use is another major function of the Water Table aquifer. Utilization of the Water Table aquifer by county is summarized in Tables 7 and 8 below. The Water Table is the source of supply for public drinking water, agriculture, landscape irrigation and commercial and industrial uses. The reliable yield of water from this aquifer provides a significant role in the economy of the region.

Table 7: Allocation of Water by Source in Million Gallons per year (as of August 2000)

Aquifers	**Lee**	**Collier**	**Hendry**	**Charlotte**	**Glades**
Surface Water	56235	43861	37966		14654
Water Table	36381	43182	7087	792	2157
Lower Tamiami	5521	53505	14256		
Sandstone	7450	7144	2980		644
Mid-Hawthorn	6023		696		2104
Floridan	22489	7774		718	

The reliable yield of the Water Table aquifer is provided through the consumptive use permit criteria. The use of the Water Table aquifer for water supply could be significantly harmed by large-scale water quality degradation (pollution and saltwater intrusion) or over-development. The District restricts permit withdrawals in order to prevent harmful movement of saltwater and point source pollution under moderate drought conditions. The Water Table aquifer is generally well protected from coastal saltwater intrusion because of the low yield of the aquifer along the coastal margin. With the exception of southern Collier County, the hydraulic conductivity of the Water Table generally less than 500 feet/day and the thickness of the aquifer is generally 40 feet or less. Further, the Water Table aquifer contains moderate levels of iron. These factors, combined with the general availability of better yielding freshwater aquifers at shallow depths, have limited the use of the Water Table aquifer near the coast. Point source contamination is limited in distribution and magnitude related to the land use of the LWC. Based on future land use plans (LWCWSP 2000) the prospect of establishing MFLs to limit groundwater contamination is not necessary.

Consideration was given to establishing significant harm based on over-development of an unconfined aquifer in the LWCWSP. Concerns were that if other water resource constraints of the water use permit program were not applicable (e.g. no wetlands, saltwater, other users, pollution etc nearby) how low could the aquifer be drawndown without losing the ability to provide water. Since the Water Table aquifer is relatively thin throughout most of its extent, it

is possible that large withdrawals or cumulative withdrawals could dewater the aquifer to a point where the drawdown characteristics reflect a confined aquifer. At some point past 50% of the saturated thickness of an unconfined aquifer, the reduction in storage causes the aquifer to cease performing like an unconfined aquifer as described by the Boulton equation, and instead exhibits drawdown characteristics of a confined aquifer with low storativity. As a result, the aquifer yield rapidly diminishes as the saturated thickness declines rendering well yields unusable. However it is also recognized that these impacts would be most severe at the well head and therefore self-limiting.

At this time, staff has not encountered these types of impacts. This is most likely due to the restrictions on the use imposed by the CUP rules. Staff is unaware of any steadfast criteria related to this type of dewatering to base a minimum aquifer level on. The District is proposing new CUP rules that will require an applicant to evaluate the possibility of this type of dewatering phenomenon when the projected maximum demands result in a drawdown of one half the pre-development thickness of the aquifer. Based on the results of such an evaluation, an alternative source of supply may be required by the permit to serve the water need during drought.

The last function that was considered for the Water Table aquifer is structural support of the substrate. The Water Table aquifer consists of basically two lithologic facies; a loosely to unconsolidated clastic sequence and a moderate to well indurated carbonate sequence. The District complied existing information on the potential for subsidence and prepared a paper for peer review (Appendix 1). The results of this preliminary study suggest that a low but real potential exist for aquifer compaction or subsidence. However, due to the lithologic framework of southwest Florida, the magnitude of the drawdown necessary to potentially cause such an impact would be larger than what exists today and on the order of 75% of the thickness of the aquifer. However, all peer reviewers agreed that additional study was necessary to better define the risks and drawdown criteria.

Summary/Recommendation:

1) With regard to the function of wetlands base flow, staff concludes that there is insufficient data available to identify the degree of hydrologic change that would produce significant harm to isolated wetland. It is recommended that the district continue to fund the on going wetland hydrologic study through its conclusion in three years and evaluate the findings through the nest LWCWSP revision process scheduled for 2005.

2) With regard to the function of baseflow to river, stream, creek, and sloughs, staff concludes that there is insufficient data available to identify the degree of hydrologic change that would produce significant harm to these water bodies. It is recommended that the specific studies needed to quantify the relationship between the Water Table aquifer at these surface water bodies be included in the scope of the South West Feasibility Study to be conducted during the nest three years. The results of the South West Feasibility Study will then be evaluated through the LWCWSP process scheduled for 2005.

3) With regard to the water supply function, staff concluded that the CUP permit criteria are sufficiently restrictive to assure sustainable yield of the aquifer and prevent harmful water

quality degradation. It is recommended that the district establish rules to require applicants with proposed drawdown of one half the pre-development saturated thickness, to evaluate the potential for dewatering the aquifer and propose alternative supplies during drought.

4) With regard to the function of structural support of the substrate, Staff concludes that there is insufficient data available to identify the degree of hydrologic charge that would produce significantly harmful subsidence. It is recommended that staff budget and construct specialized monitor station to measure subsidence at select stations and evaluate the results through the next LWCWSP revision process scheduled for 2005.

As a result of the lack of technical data to determine significant harmful hydrologic variation to natural system and considering the on going research projects underway and the protection afforded by the District CUP program, it is recommended that an MFL for the Water Table aquifer be delayed until the research has been completed.

Lower Tamiami, Sandstone and Mid-Hawthorn aquifers: The two water resource functions associated with all three of the semi-confined aquifers are 1) water supply and 2) structural support to the overburden. Reduction in water levels could effect the water supply function of these aquifers through induced movement of saline water to an extent where the water quality in the aquifer is not usable for the use intended. As described in Chapter 2, there are limited sources of saline water within the Lower Tamiami aquifer (along the coast), Sandstone (no real source of saline water) and the Mid-Hawthorn. Further, the District's CUP rules and water shortage rules are geared towards regulating withdrawals that would cause saltwater migration (see CUP protection discussion below). Water quality data collected over the past twenty years show these regulations have been successful in limiting harmful movement of saltwater. Therefore, no changes or an additional protective criterion to regulate saltwater movement is recommended.

Another factor that could significantly harm the water supply function of these aquifers is if water levels drop to a point where the aquifer yield diminishes. A reduction in aquifer yield could result if water levels dropped to point where the clayey confining beds compacted to a degree where vertical recharge was restricted. Another condition that could result in a reduction of aquifer yield would be if the water level dropped below the top of a confined aquifer introducing air into the unit. This condition presents several problems including gas binding; dissolved mineral instability as a result of changed pH and pH, water quality changes and dewatering. Shifts in redox potential resulting from introducing air into the anaerobic semi-confined aquifers would effect several of the naturally occurring chemical species including iron, calcium carbonate, and sulfur compounds. Such changes could drive precipitation/solution reactions changing the water quality within the aquifer as well as the physical properties of the aquifer itself. These types of geochemical changes could occur rapidly so that exposures of only a few days could be significantly harmful.

Inherent with water level declines of this magnitude is the structural stability of the overburden. The lithostratigraphy of southwest Florida is layered limestones, clays/silts and sands. Decreases in hydrostatic pressure in confined aquifers result in increased grain to grain contact load on the sediments. The sediments compact in response to the added load and the land surface subsides. Chief controlling factors in the potential for subsidence are the number,

thickness, compressibility, and permeability, of the fine grained interbeds and confining beds, clay mineralogy, geochemistry of the pore fluids in aquifers and aquitards, initial porosity, previous loading history and cementation (Poland and Davis, 1969). The degree of compaction is related to the amount of time the water levels are depressed. However, once the compaction potential is achieved, whether fast or slow, further compaction won't occur unless additional drawdowns are imposed. This is relevant in the study area as groundwater levels are thought to have been much lower during the ice ages than in modern times. This is evidenced by the paleo-karst like features found in eastern Lee County.

Utilizing a method for estimating compaction set forth in Freeze and Cherry (1979), and estimated values for compressibility associated with the earth materials found in the LWC strata, staff estimated a limit for drawdowns at 75% of the distance between the average pre-development potentiometric head and the structural top of the aquifer. This guideline is being considered in the establishment of maximum developable levels for CUP allocation criteria. This proposed permitting criteria would limit drawdowns to levels above these compaction guidelines. Reductions in the potentiometric head below these guidelines would be considered increasingly harmful to the aquifer.

Summary/Recommendation: 1) Based on the information presented for the protection of the water supply and structural stability functions of the Lower Tamiami, Sandstone and Mid-Hawthorn aquifers, Staff recommends that significant harm would occur if water levels dropped to the top of the aquifer for any length of time. 2) It is recommended that the District conduct research to better quantify the potential for subsidence within the study area. This research should include the construction of specialized subsidence monitor wells in areas where the greatest potential drawdowns will occur and also conduct compaction testing on lithologic core samples. 3) The District should adopted new CUP criteria to define the maximum developable levels for each of these aquifers to prevent subsidence up and including a 1 in 10 drought condition. In addition, the District should modify its water shortage rules 40E-22 F.A.C. to define the maximum developable levels as criteria to be considered in the declaration of water shortage and the imposition of mandatory water use cutbacks.